

Remarks

These remarks are presented in response to the Office Action mailed March 31, 2003. In response to that action, all of the pending claims have been cancelled and a new set of claims has been presented. Reconsideration of these new claims, in view of the following remarks, is respectfully requested.

The Examiner rejected claims 11-17 under 35 USC §112, second paragraph, as being indefinite because the Examiner asserted that the metes and bounds of the term "substantially" was indefinite. The Examiner will note that this term has not been used in the new claims.

The Examiner rejected claims 1 and 10 under 35 USC §102(b) as being anticipated by U.S. Patent No. 4,233,274 to Allgulin ("Allgulin"). The Examiner asserted that Allgulin teaches oxidizing mercury in a flue gas with oxidizing agents such as chlorine. The Examiner further stated that Allgulin teaches subsequent precipitation via sulfide ions and that example 1 shows that the selected temperature of the flue gas allows for the use of aqueous species and low temperature gases to oxidize the mercury.

The Examiner also rejected claims 1 and 10-12 under 35 USC §103(a) as being unpatentable over Allgulin. The Examiner cited Allgulin for the same teachings as used in the §102(b) rejection and further concluded that it appears that substantially all of the elemental mercury vapor is converted to oxidized mercury in example 1. However, in this example, Allgulin cites mercury reduction from a starting point of 4 mg Hg⁰/Nm³ to a final concentration of 0.02 mg Hg⁰/Nm³. In contrast, the example given at pages 8-10 of Applicants' specification actually provides a **starting** concentration (20 µg/Nm³) that is equivalent to the final removal concentration taught by Allgulin. Thus, irrespective as to questions of indefiniteness, the Applicants' previous use of the phrase "wherein substantially all of the mercury is removed" must be at a concentration that is significantly lower than the actual removal capabilities taught by Allgulin, and Applicants respectfully submit that the Examiner's conclusion in this respect is somewhat misplaced. Moreover, for reasons that will be discussed in greater detail below, Applicants further submit that the process and teachings of Allgulin would not permit refinement of that process to achieve the results obtained by the Applicants' invention.

The Examiner further rejected claims 1, 4 and 10-12 under 35 USC §103(a) as being unpatentable over WO 99/58228 ("WO 228") in view of Allgulin. The Examiner states that WO 228 teaches a process for oxidizing gaseous pollutants in a flue gas stream containing mercury vapor whereby chlorine in gaseous form, liquid form or as a water solution is injected into the mercury containing gas at temperatures greater than 100° C to oxidize the chlorine. While conceding that WO 228 does not teach subsequent use of sulfides to precipitate mercury, the Examiner nevertheless concluded that the subject matter as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made to select the portion of the prior art's range of temperatures for oxidizing the mercury which is within the range of the Applicants' claims because it has been held to be obvious to select a value in a known range by optimization for best results. The Examiner further concluded that the teaching of Allgulin to oxidize mercury in the flue gas through the use of oxidizing agents such as chlorine, coupled with subsequent precipitation with sulfide ions and the aforementioned similarities alleged by the Examiner with respect to temperature and removal capabilities, render Applicants' invention obvious insofar as those skilled in the art would look to WO 228 to oxidize mercury in conjunction with the teachings of Allgulin. Citing *In re Kamlet*, 88 USPQ 106, the Examiner finally concluded that WO 228 creates a product which can be used as a reactant in a subsequent reaction according to the teachings of Allgulin because the materials are similar and the "other process" requires the product.

The Examiner also rejected claims 1-14 and 16-18 under 35 USC §103(a) as being unpatentable over U.S. Patent No. 6,214,304 to Rosenthal et al. ("Rosenthal") in view of U.S. Patent No. 5,009,871 to Higuchi et al. ("Higuchi"). The Examiner stated that Rosenthal teaches cooling a flue gas to below 300° C (preferably below 200° C), oxidizing the mercury and adding an alkali sulfide to precipitate mercury. While the Examiner admitted that Rosenthal does not disclose chlorine or oxi-acid species containing chlorine as an oxidizing agent, the Examiner nevertheless concluded that the other aspects of Applicants' claims were obvious as a matter of optimization. The Examiner also concluded that Higuchi teaches use of hypochlorite, hypochlorous acid and their salts to oxidize mercury, such that one of ordinary skill in the art would modify Rosenthal by using the oxidizing agents of Higuchi and by using the alkali wash

solution of Higuchi in the Rosenthal process even though Rosenthal does not explicitly contemplate such a step. In short, the Examiner concluded that it would be obvious to combine processes known to work separately for their added effect.

The Examiner also rejected claims 1, 4 and 10-12 under 35 USC §103(a) as being unpatentable over Rosenthal in view of WO 228. The Examiner concluded that it was a matter of optimization to use the teachings of Rosenthal and to further combine the teachings of WO 228 with Rosenthal.

Finally, the Examiner rejected claims 1-14 and 16-18 under 35 USC §103(a) as being unpatentable over Higuchi in view of EP 0709128 ("EP 128"). The Examiner stated that Higuchi teaches use of hypochlorite, hypochlorous acid and their salts to oxidize mercury and that Higuchi appears to convert substantially all of the elemental mercury on the basis of Higuchi's Tables 1 and 2, although Applicants respectfully note that these tables merely refer to "Percentage removal of mercury" according to certain oxidizing agents and that the best instance of removal was only 88% which, irrespective of indefiniteness concerns, is not the equivalent to the level of mercury removal achieved by the Applicants' invention. The Examiner also noted that Higuchi uses alkali solution to remove mercuric chlorides, cools the gas to 300° C prior to washing with oxidizing agents and that it appears the temperature would continue to decrease. Although the Examiner concedes that Higuchi does not teach removing oxidized mercury subsequent to and separate from the chlorine treatment, the Examiner concluded that the differences between Applicants' claims and Higuchi were merely a matter of optimization in the absence of unexpected results. The Examiner also points to EP 128 to demonstrate that it would be obvious to oxidize mercury according to Higuchi and then remove this oxidized mercury according to tetrasulfide use as taught by EP 128, again citing *In re Kamlet*.

As indicated above, the Examiner will note that claims 1-18 have been cancelled in favor of new claims 19-25 which more particularly and clearly define and describe Applicants' claimed invention. As such, claims 19-25 are the only claims still pending in the case.

The sole independent claim has been recast to emphasize the differences between Applicants' invention and the art of record. Foremost, new claim 19 now clarifies that Applicants' invention is intended to act upon flue gases containing only low levels of mercury

and that it is expected to remove essentially all mercury from that flue gas. As indicated in a recent study known as the Information Collection Request (ICR) conducted by the United States Environmental Protection Agency, typical coal-fired utility boilers (to which the method of the present invention is particularly directed) produce boiler flue gases with total mercury concentrations which are generally less than $50 \mu\text{g}/\text{Nm}^3$ and only a portion of that mercury will be Hg^0 . As such, Applicants' claims represent a substantial and unexpected improvement over Allgulin, wherein large quantities of mercury were removed from a flue gas to produce an end product with a mercury concentration equivalent to the flue gases which Applicants' claimed invention is specifically designed to clean. More importantly, the differences between Applicants' process and that taught by Allgulin preclude the refinement of Allgulin's teachings to achieve the results produced by Applicants' claims.

In particular, Allgulin depends upon the presence of a scrubbing liquor deliberately provided with a small amount of mercury (II) ions and at least double that content of ions possessing the ability to form soluble complexes with mercury (II) ions. Allgulin goes on to explain, at col. 3, lines 42-44 that, for its invention to operate, it is necessary maintain soluble mercury (II) ions in the scrubbing liquor itself. The deliberate presence of this soluble mercury species is necessary to form the $(\text{Hg}^{2+})\text{-X}$ complex indicates that Allgulin relies upon an entirely different chemical methodology for the removal of mercury from its flue gases. As an aside, the requirement for small levels of soluble mercury within the scrubbing liquor might also explain why Allgulin's mercury removal capabilities are incompatible with the level of removal required and achieved by more recent methods (including the Applicants' invention). In any event, Allgulin explicitly states at Col. 3, lines 36-38 that the washing liquor captures the mercury as Hg_2X_2 , or per the Examiner's implication (and the explicit teachings of Allgulin at col. 4, lines 23-32), Hg_2Cl_2 .

This utilization of mercury complexes differs from the Applicants' method. Applicants forego such mercury complexing agent-laden scrubbing liquors, along with the need to maintain mercury (II) ions therein, in favor of oxi-acids or chlorine. Moreover, it was Applicants alone who established that, through the combined use of a sulfide containing solution and a gas-liquid interface generating wet scrubber, Applicants' process actually precipitates the mercury as HgS

in situ—that is, the mercury is captured in solid form within the wet scrubber itself. Thus, Applicants use a different chemical process to achieve a different, and in terms of overall mercury removal, much better result.

WO 228 similarly fails to teach or suggest Applicants' claimed invention. While Applicants concede that, in some respects, WO 228's teachings are closer in terms of the chemical pathways than those of Allgulin, it is extremely significant to note that, as with Allgulin, WO 228 fails to suggest a means for precipitating the oxidized mercury within the scrubbing liquor itself. That is, WO 228 neither teaches nor suggests the concurrent use of sulfides, in conjunction with an oxidizing reagent containing chlorine (such as oxi-acids), in order to capture mercury within the wet scrubber itself. Instead, as is the case with Allgulin, WO 228 requires an external precipitation step wherein the solution containing the oxidized mercury is drawn off and separately precipitated out of solution. Also, to the extent that WO 228 depends upon a pH-adjusted water scrubbing solution, Applicants' invention further differs from this reference insofar as Applicants' method can be incorporated directly into existing alkali-based wet scrubbing desulfurization equipment.

Turning next to the Higuchi reference, the Examiner's attention is particularly drawn to col. 2, line 62-col. 3, line 2. In essence, Higuchi suggests that use of any oxidizing agent should be extremely limited so as to avoid corrosion. In contrast, Applicants' preferred embodiment calls for addition of both oxidizing reagent and mercury-precipitating sulfides at stoichiometric ratios well above the normal amount (for example, see page 9, line 7-page 10, line 4). Thus, at first blush, Higuchi would seem to teach away from the Applicants' invention. Also, as will be appreciated by those skilled in the art, the incinerator flue gases discussed throughout Higuchi are notoriously high in mercury concentrations, thereby leading to similar issues as with the Allgulin reference (also refer to the comments regarding Higuchi's Tables 1 and 2, above). But finally, and most significantly, Higuchi also fails to teach or suggest a means of concurrently removing oxidized mercury through its *in situ* precipitation within the confines of the wet scrubber.

Reliance upon Rosenthal to defeat the patentability of Applicants' invention is similarly misplaced. Whereas Rosenthal does contemplate use of an alkali-based scrubbing reagent to

capture mercury as HgS (unlike Allgulin, WO 228 or Higuchi above), Rosenthal nevertheless relies upon a much different physical means of capturing the mercury sequestered by its method. In particular, at col. 3, lines 5-19, Rosenthal describes that mercury removal is not achieved in the scrubber. Instead, Rosenthal incorporates a *post-hoc* condensation of water droplets onto dust particles in a wet electrostatic filter in order to capture the HgS generated thereby. Also, while Rosenthal does provide two off-hand remarks concerning the preferred use of an oxidizing agent such as H₂O₂, O₃ or NaOCl, no suggestion or implication is provided as to the utility of this step. Thus, Rosenthal provides no guidance or motivation to those skilled in the art to further explore or consider the use of other oxidizing agents differing concentrations thereof. More significantly, this silence as to oxidizing agents, coupled with the fact that Rosenthal and the present invention both rely upon a much different mercury precipitation and removal method, means that one skilled in the art would see no need to consult the teachings of Allgulin, WO 228 or Higuchi to consider other oxidizing agents.

Finally, with respect to EP 128, no teaching or suggestion is made with respect to the combined use of an oxidizing reagent with a sulfide to capture, within the confines of a wet scrubber, all forms of mercury from a flue gas. Instead, this reference focuses upon the use of sodium polysulfides to precipitate mercuric sulfide, which is subsequently captured by passing the gas through a dust filter. As with Rosenthal, this difference in the physical means of capturing the mercury requires additional structures and associated costs.

Thus, Applicants alone determined a means for capturing mercury within a wet scrubber and without the need for downstream treatment of the flue gas exiting from the scrubber. Applicants' method contemplates the novel, and heretofore unknown, combination of oxidizing agents and sulfides to achieve these beneficial results in an efficient and economical manner. Applicants aver that this combination is novel for numerous reasons, as discussed in their specification produced unexpected results and more generally was not anticipated if for no other reason than, despite the numerous references seemingly on point, no one has previously claimed this particular combination.

It is important to bear in mind that oxidizing agents are well known and number in the hundreds, if not thousands. The chemical properties of these agents can vary widely, especially

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when coupled with specific conditions, reactants and temperatures. Thus, it would be an improper hindsight reconstruction to merely insinuate that mention of a particular oxidizing agent for a particular application makes that agent directly and easily incorporated into any other reaction which requires an oxidizing agent. Stated more simply, absent a clear teaching, it is improper to incorporate the teachings of a mercury removal scheme which relies upon precipitation of mercury via sulfide with other precipitation schemes.

In light of the foregoing, Applicant respectfully submits that, by this amendment, the present application is now in condition for allowance, and such action is respectfully requested.

Respectfully submitted,

Eric Marich, Reg. No. 32,265
Attorney for Applicants

The Babcock & Wilcox Company
1562 Beeson Street
Alliance, OH 44601
(330) 860-6710